Modeling Global Influenza Risks Using NASA Data

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OUTLINE

Objectives

Collaborators

Background

- Epidemic-prone respiratory diseases
- National preparedness policy
- H3N2v currently in the US
- Human, swine and avian influenza

Disease Burden

Climatic and Environmental Dependency

Accomplishments

- Outreach to and interactions with collaborating countries
- Climate & Influenza Circulation Workshop
- Central America results

Risks

Budget

Plan for the Remaining Period

OBJECTIVES

Using NASA and other data, examine how influenza circulation is affected by meteorological, environmental or other factors at major population centers around the world. Develop predictive models if there is significant dependency on these factors. Share results with public health stakeholders to strengthen their influenza surveillance and response capabilities.

COLLABORATORS

- CDC
- WHO
- Public health agencies in collaborating countries:

  National Influenza Center, Guatemala
  National Influenza Center, Panama
  Health Surveillance Center, El Salvador
  Robert Koch Institute, Germany
  Institute of Public Health, Norway
  Statens Serum Institute, Denmark
  Consejería de Sanidad, Spain
  Centre for Disease Control, Israel
  National Institute of Public Health, Slovenia
  Medical Research Institute, Kenya
  Health Protection Agency, United Kingdom
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Epidemic-prone acute respiratory diseases have no borders, and can be spread rapidly around the world. Global, coordinated surveillance & control efforts are essential.

2003 SARS

Spread to 37 countries in weeks

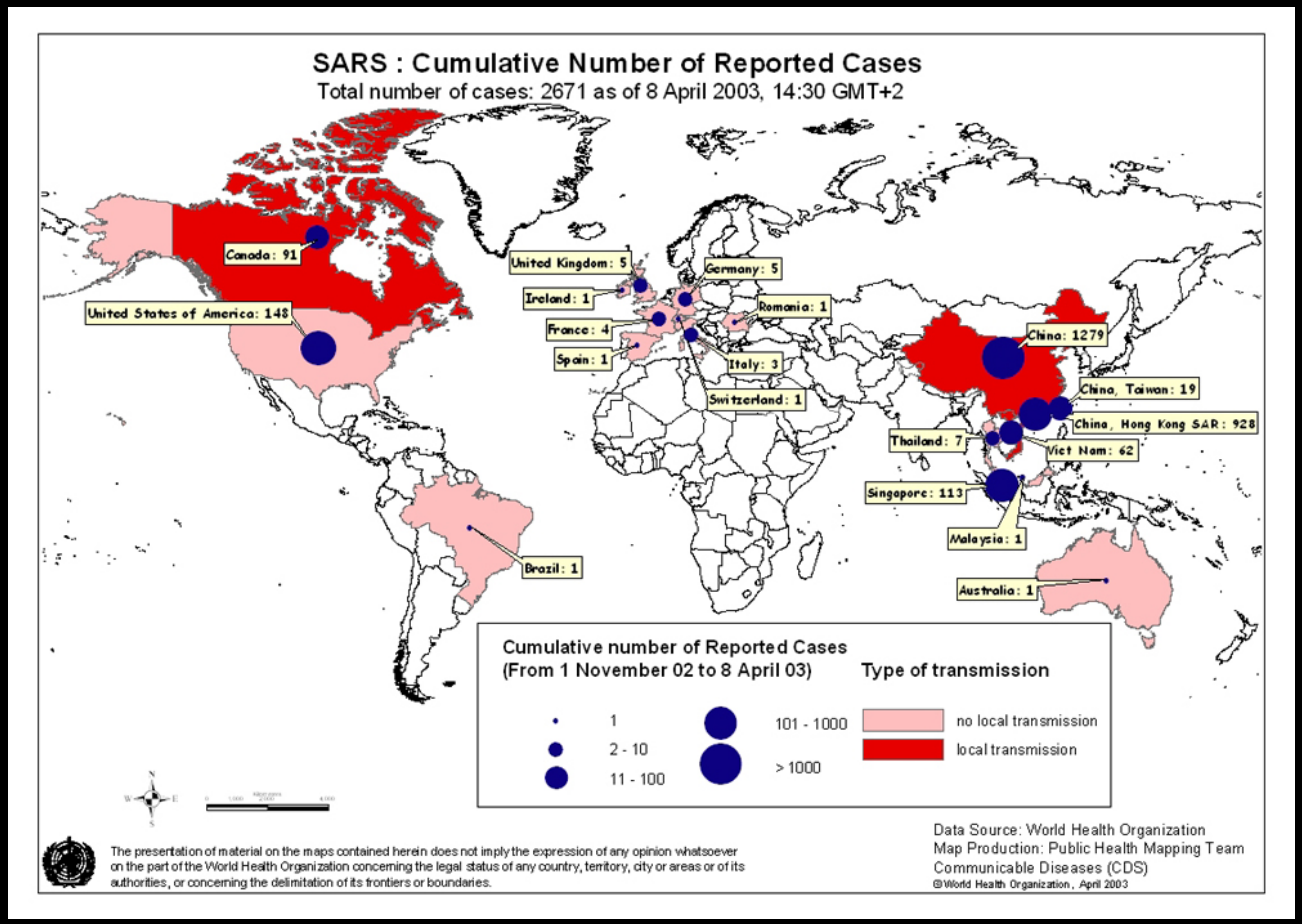
2004 Avian Influenza – A(H5N1)v

Spread to 62 countries since 2004. There are still frequent outbreaks in Indonesia, Egypt, and some Southeast Asian countries.

2009 Pandemic – A(H1N1)pdm09

Spread to 48 countries in a month despite heightened public awareness and substantial preventive and control efforts

The 2003 SARS Outbreaks



Human coronavirus

SARS increased public health as well as the general public's awareness of the seriousness of pandemic, and provided a real test ground for preventing and controlling respiratory disease.

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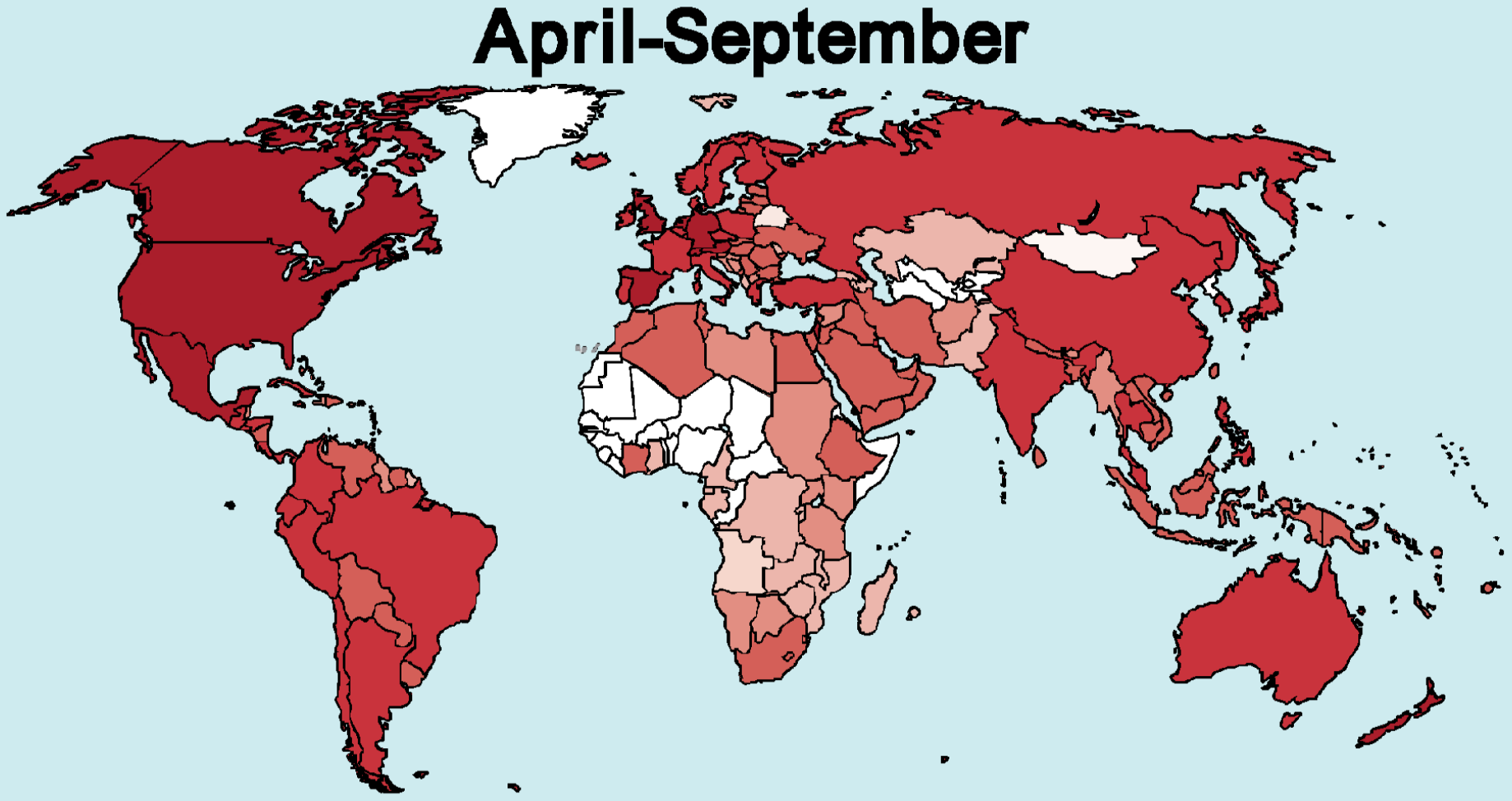
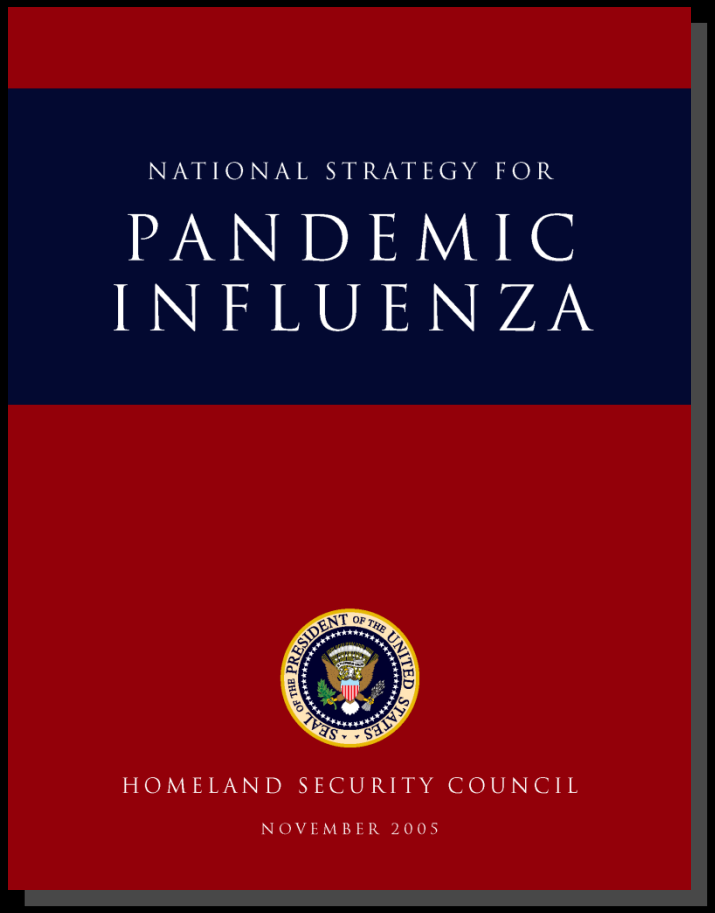
Global Spread of Pandemic H1N1 2009



National Strategy for Pandemic Influenza



Three Pillars:

- Preparedness & Communication
- Surveillance & Detection
- Response & Containment

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H3N2v Cases Since 12/11/2011

A/California/7/2009 (H1N1)-like ← A(H1N1)pdm09

A/Victoria/361/2011 (H3N2)-like

B//Wisconsin/1/2010-like (Yamagata)

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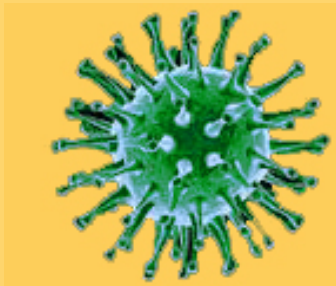
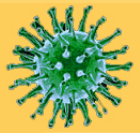
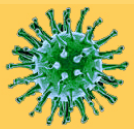
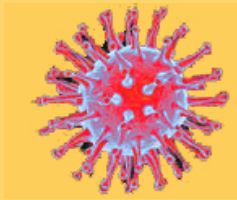


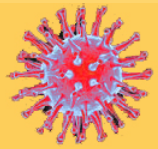


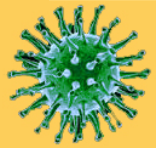


SA α2,6-Gal

SA α2,3-Gal

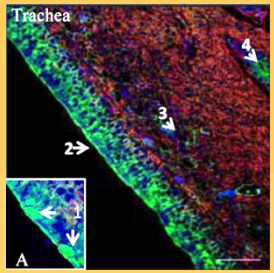






SA α2,3-Gal
SA α2,6-Gal

SA α2,3-Gal



Receptors in porcine trachea
Nelli et al. 2010

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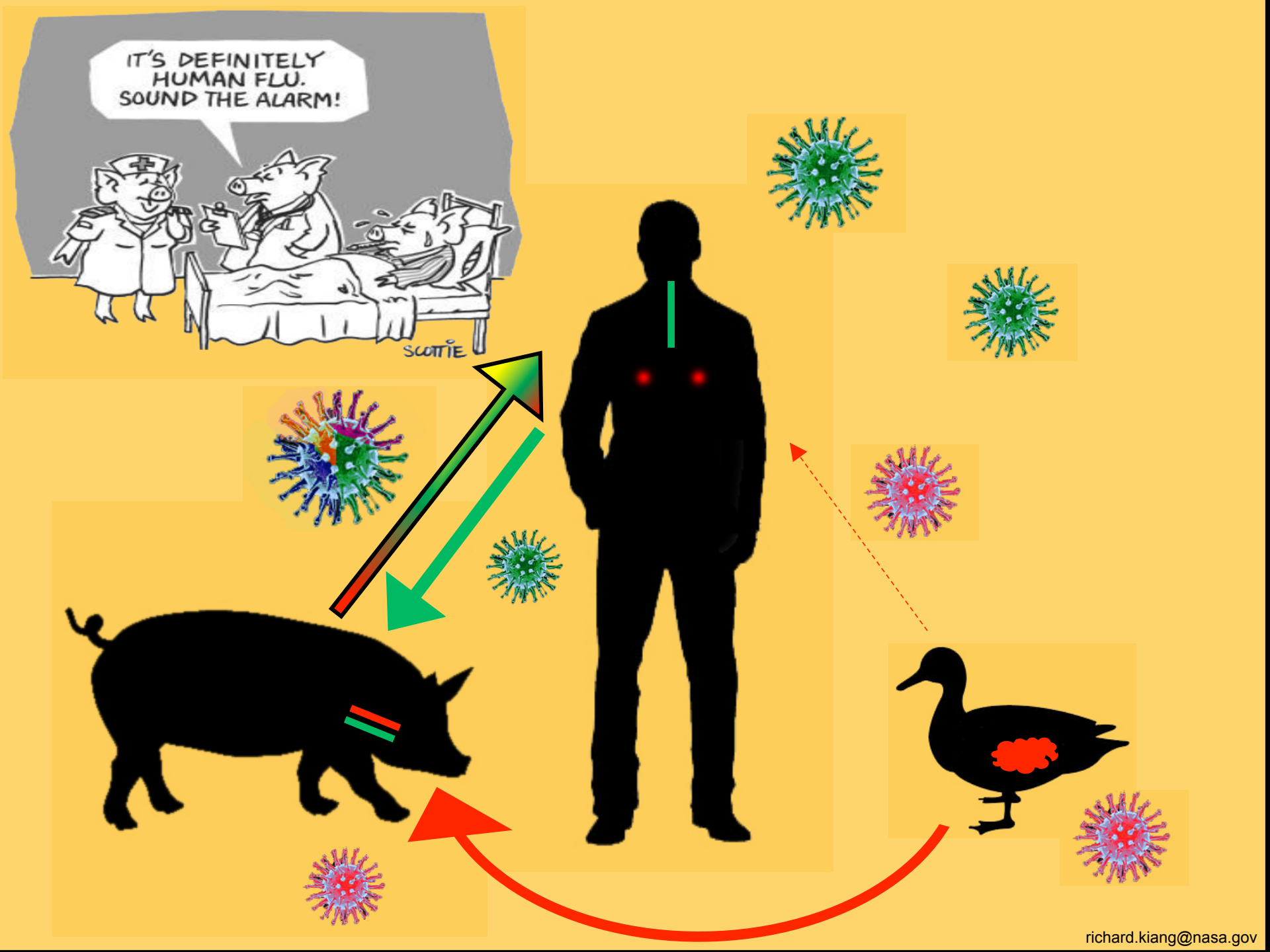

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Burden of Influenza

US

- 0.2 M hospitalizations and 36,000 deaths annually
- Hospitalization rate highest in children
- 90% of deaths are older than 65 years
- 75% of deaths are not coded pneumonia or influenza

World

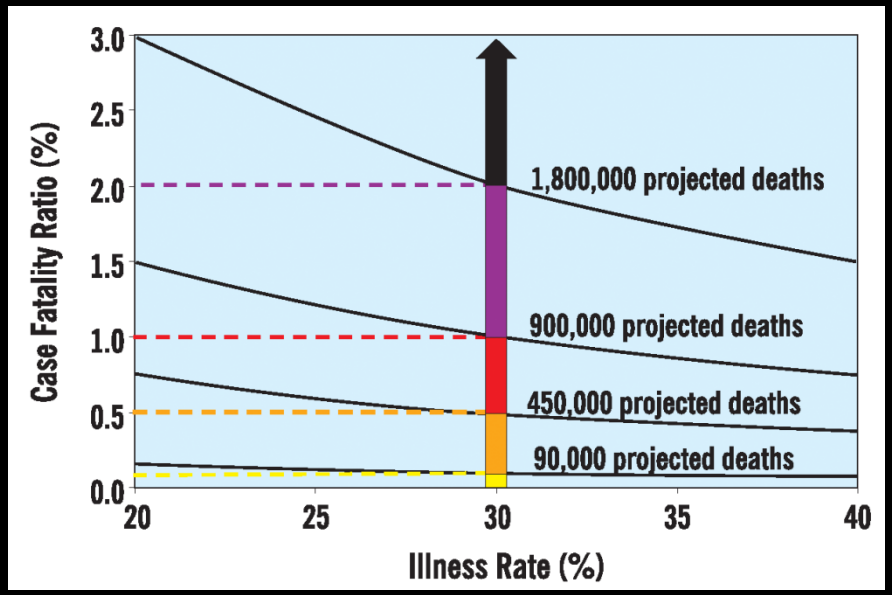
- 3-5 M severe cases annually
- 0.25-0.5 M deaths annually

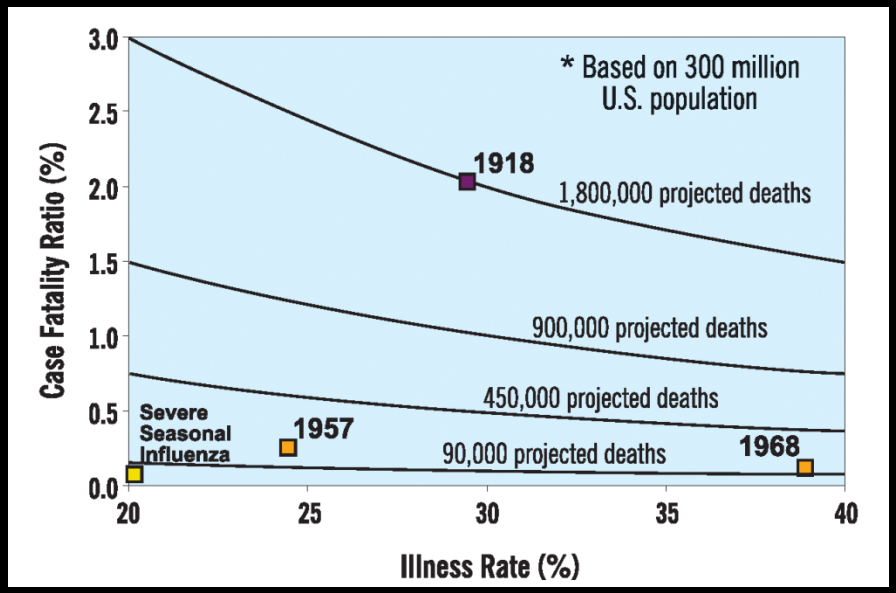
Economic Burden

- Direct health care?
- Societal costs?
- Nearly $10 B annual economic loss for US alone

Sources: WHO, Thompson et al., Widdowson

Projected Deaths in US
For Pandemics With Severity 1-5





Category	CFR
1	< 0.1 %
2	0.1 - 0.5 %
3	0.5 - 1.0 %
4	1.0 - 2.0 %
5	> 2.0 %

Pandemic	Deaths in US
1918 Spanish Flu	~ 500 K
1957 Asian Flu	70 K
1968 HK Flu	34 K

Source: USG Prepandemic Plannig Guidance

Environmental & Sociological Factors Affecting Human Influenza Transmissions

Change in Transmission with Increase in Factor

Virus Survivorship	Temperature	↓
	Humidity	↓
	Vapor pressure	↓
	Solar irradiance	↓
Host Susceptibility	Sunlight exposure	↓ ↓
	Nutrition	varies
	Previous infections	↓ ↓
Transmission Efficiency	Temperature	↓ ↓
	Humidity	varies
	Vapor pressure	↓ ↓
	Precipitation	↑
	ENSO	↑
	Air travel	↑
	Holidays	↑

Biological Evidence
Empirical Evidence

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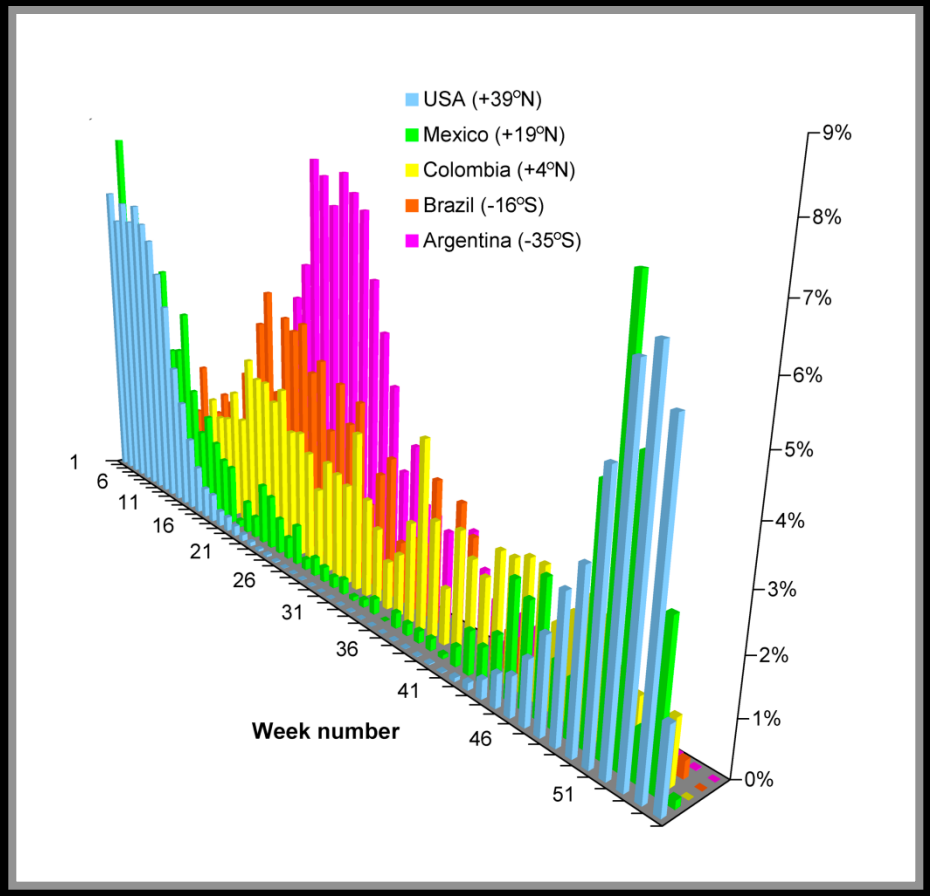
Empirical Evidences of Environmental Influences On Influenza Transmissions



Viboud et al. (2006). PLoS Med 3(4):e89

- Latitudinal variability in influenza transmission pattern
- Experimental findings on the effect of meteorological factors in influenza transmission, virus survivorship and host susceptibility

Discussed	Showed Interest	Sent Data	Other Sources
			Belgium
Cambodia	Cambodia		
			Czech Republic
Denmark	Denmark		
El Salvador	El Salvador	El Salvador	
Germany	Germany	Germany	
Guatemala	Guatemala	Guatemala	
Indonesia	Indonesia		
Israel	Israel	Israel	
Kenya	Kenya	Kenya	
			The Netherlands
Norway	Norway	*Norway* *	
Panama	Panama	Panama	
Russian Federation	Russian Federation		
			Singapore
Slovenia	Slovenia	Slovenia	
South Africa	South Africa		
Spain	Spain	Spain	
Switzerland	Switzerland		
Thailand	Thailand		
UK	UK		

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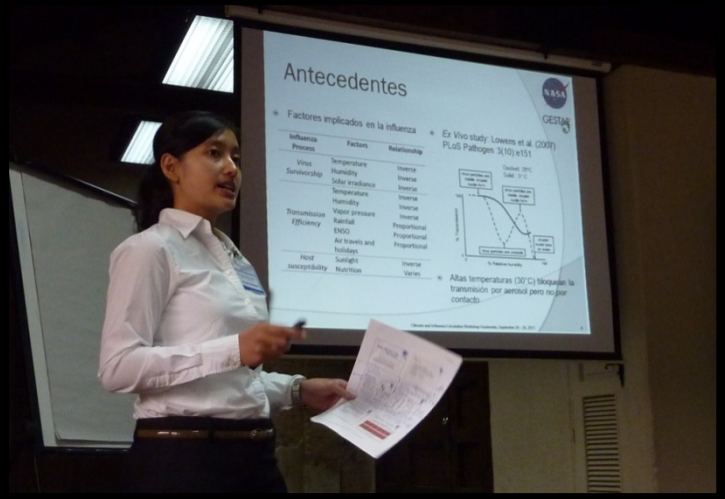
Climate and Influenza Circulation Workshop

Antigua, Guatemala, September 26-27, 2011

Taller sobre Modelizacion y Circulacion de Influenza, Basado en Mediciones Climaticas, Meteorologicas y Ambientales



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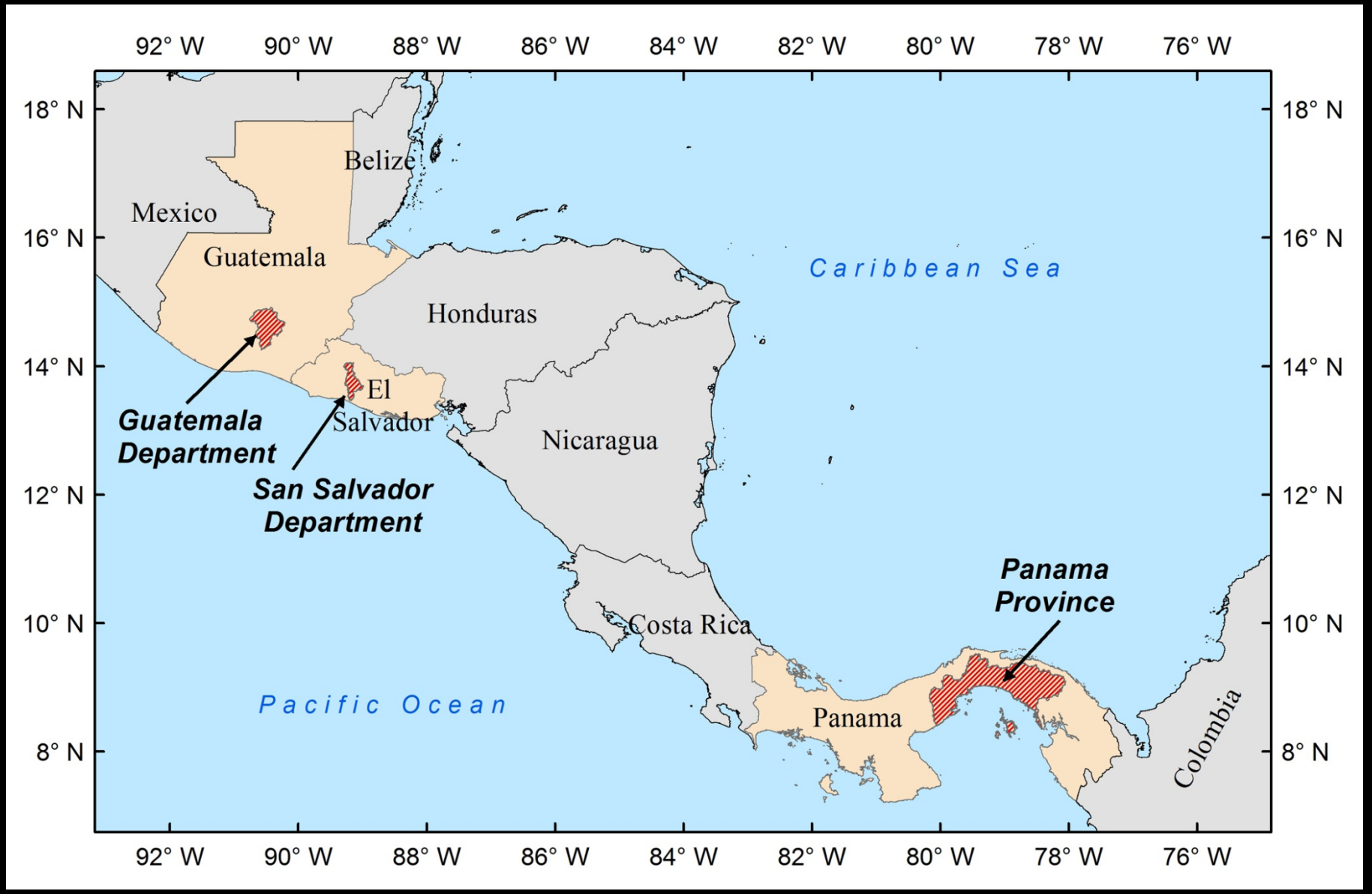
Study Areas in Central America



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INFLUENZA DATA

Diagnosis of influenza through detecting:

Live virus

Viral culture – necessary for strain surveillance & vaccine strain selection and production

Viral protein (antigen)

Rapid detection kits – for typing only; false negative

Immunofluorescence assay – for typing/subtyping

Viral genetic material (nucleic acid)

RT-PCR – for typing/subtyping

Immune antibody

Serologic tests – collection time important

METEOROLOGICAL DATA

- **NASA Satellites**

  TRMM – precipitation

  MODIS – land surface temperature

- **NASA Climate Model**

  GLDAS – precipitation, temperature, specific humidity

- **Ground Stations**

  min/max/mean temperature, relative humidity, dew point , solar irradiance, etc.

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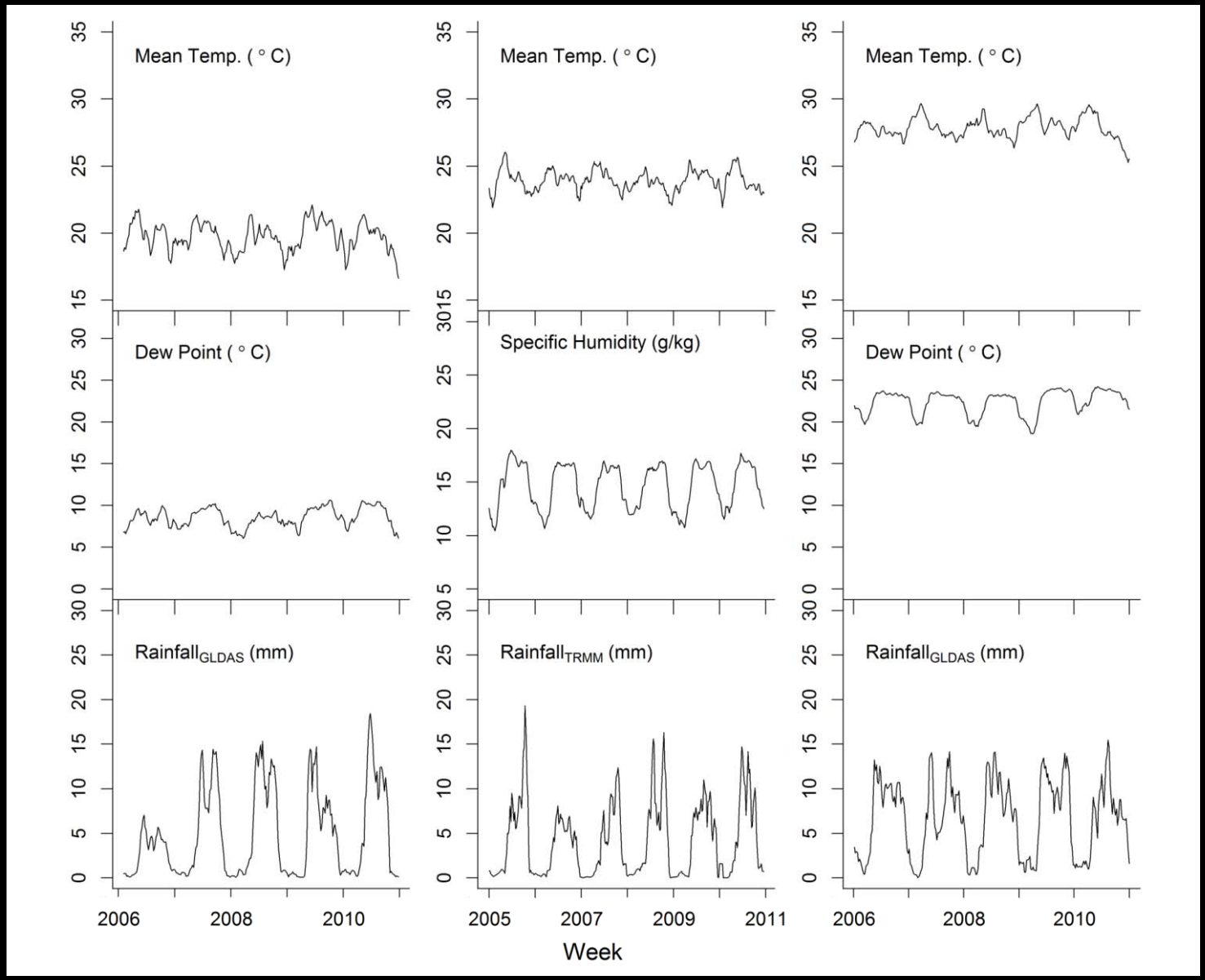
Meteorological Parameters



Parameters with Significant Influence On Influenza Circulations

Guatemala Department, Guatemala

$R^2 = 0.64$

Mean temperature: RR = 2.6, 95% CI = 1.8 ─ 3.7

Precipitation: RR = 1.1, 95% CI = 1.0 – 1.2

Panama Province, Panama

$R^2 = 0.64$

Mean temperature: RR = 3.4, 95% CI = 2.2 – 5.2

Precipitation: RR = 1.2, 95% CI = 1.1 – 1.3

San Salvador Province, El Salvador

$R^2 = 0.51$

Specific humidity: RR = 2.5, 95% CI = 1.9 – 3.3

Increments: 1°C in temperature, 1 mm in precipitation, 1 g/Kg in specific humidity.

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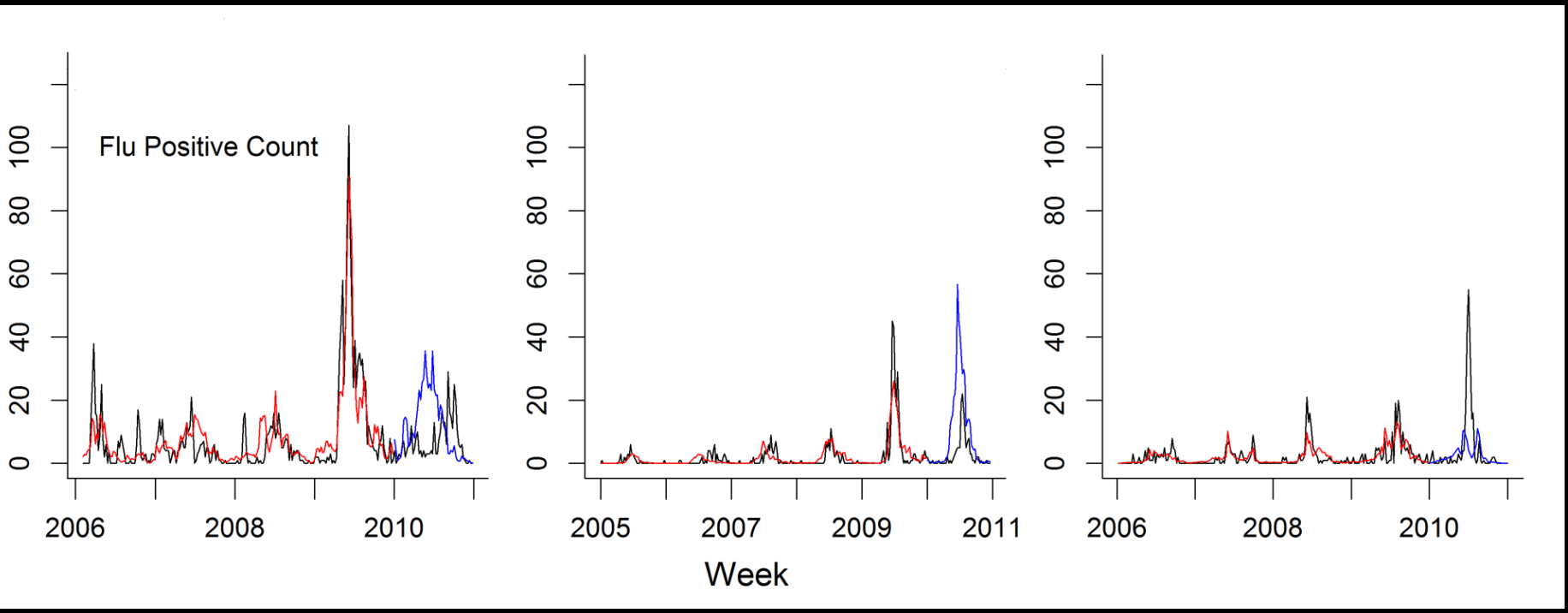
Actual and Modeled Influenza Cases

Guatemala Dept. San Salvador Prov. Panama Prov.



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RISK AREAS

INFLUENZA DATA

- Data Availability
- Data Accuracy
- Data Paucity

SATELLITE DATA

- Data Availability

GROUND STATION DATA

- Data Accuracy
- Data Paucity

BUDGET

Second Year Funding: $75,598

(2/15/2012 – 2/14/2013)

PLAN FOR THE REMAINING PERIOD

- Publish Central America results
- Complete analyses and modeling for some of the remaining countries
- Outreach to additional countries if needed
- Write manuscripts for the remaining countries
- Write final report


THANK YOU